WATER QUALITY CONSIDERATIONS FOR HIGHWAY PLANNING AND CONSTRUCTION

I-70 VAIL PASS COLO.

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I-70 VAIL PASS, COLORADO

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ABSTRACT

Soil erosion and sediment control have long been concerns associated with road construction activities. Several manuals have been written on the subject, providing excellent guidelines for estimating costs and implementing control measures. The construction of a four lane highway over Vail Pass, Colorado, has provided the opportunity to implement many of these control measures on a sensitive, high elevation, mountain pass. This report evaluates the performance of these erosion and sediment control structures. The results are considered representative of what might be expected in other steeply dissected, mountainous terrain. These measures are applicable to other land-disturbing activities, including: timber sales, mining operations, ski areas, and all construction sites.

ACKNOWLEDGEMENTS

We would like to take this opportunity to thank the Colorado Division of Highways for their cooperation in the design and implementation of many of the erosion control techniques outlined in this report. It was this cooperative effort between the Colorado Division of Highways and the United States Forest Service that resulted in the protection of the environment while constructing an interstate highway over Vail Pass.

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INTRODUCTION

Interstate 70 over Vail Pass is located in the central Rocky Mountains, southeast of Vail, Colorado (Figures 1, 2). Construction of a four lane highway over this high elevation mountain pass began in 1973 and is scheduled for completion in 1979. The highway parallels West Tenmile Creek on the east side of the pass and Gore Creek on the west. Both creeks are municipal water supplies and are important for recreation, fisheries, aesthetics and agricultural uses. Soil erosion and water quality protection were key considerations in the design and construction of the highway.

The alignment of the 17.6 mile stretch of road was limited by the steep mountainous topography, necessitating construction through highly erodible soils and isolated areas of active landslides. Soon after construction began, several soil erosion and water quality problems were encountered, despite conventional control efforts. As a result, many new and innovative erosion control measures were implemented on the project. This report examines these erosion control methods and discusses their effectiveness for a sensitive mountain environment.

PROJECT EVOLUTION

The procedures for Forest Service involvement related to public highway projects over National Forest lands is an involved process which starts with project planning and extends throughout the construction period. The specific procedures normally followed are outlined in Forest Service Manual 2730.

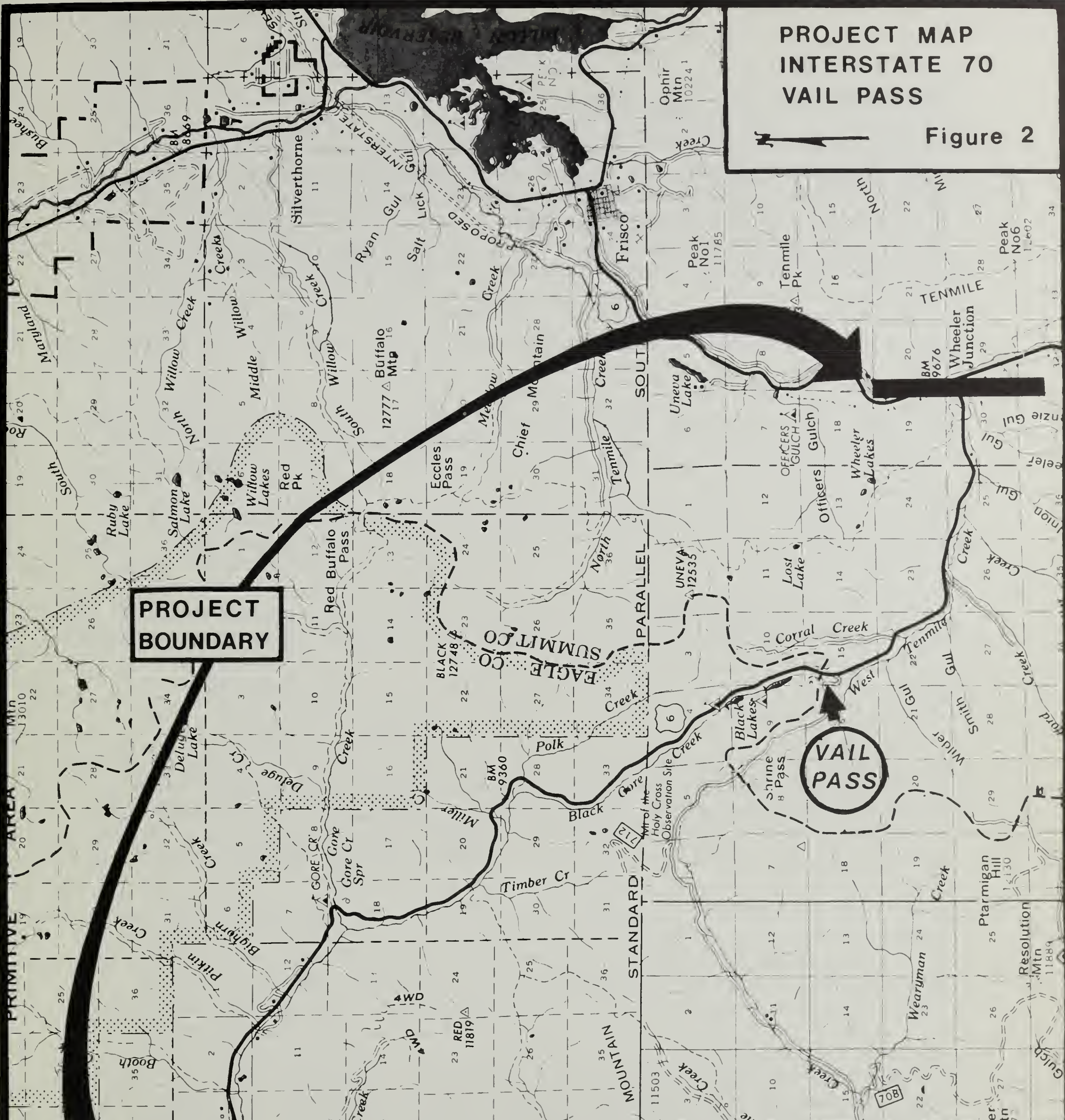
It was clear however, that due to the sensitive sub-alpine environment at Vail Pass, additional water quality stipulations were necessary to protect the soil and water resources. The stipulations were agreed upon by the Colorado Division of Highways and the U.S. Forest Service (Appendix A). These stipulations addressed fish habitat, stream crossings, disposal of waste materials and limitations on construction machinery in or near stream courses. They were requirements and conditions made for the State of Colorado in order to obtain an easement deed from the United States.

To meet the constraints set forth in the stipulations, the Forest Service developed guidelines that would maintain water quality during and after highway construction. These guidelines were published as part of the Landscape and Erosion Control Manual prepared by the International Engineering Company for the Colorado Department of Highways. The Manual served as a guide for the design and construction of the highway projects on Vail Pass. It discussed various techniques for landscape design, erosion control, revegetation and control of water runoff.

PROJECT VICINITY
INTERSTATE 70
VAIL PASS, COLORADO

Figure 1

PROJECT LOCATION



PROJECT MAP
INTERSTATE 70
VAIL PASS

Figure 2

Water Quality Monitoring Program

To determine the effectiveness of these guidelines, Part I of a two phase sampling program was established (Appendix B). Its goals were to gather baseline chemical and sediment data prior to construction for the three principal drainages, West Tenmile Creek, Gore Creek, and Black Gore Creek and to continue collection of this data throughout the entire construction project. This was done to determine the overall impact of the construction of I-70 over Vail Pass on water quality and the effectiveness of the water quality constraints. This information is still being collected and, following the completion of the highway, an evaluation report will be prepared.

At the time the highway was designed, the State of Colorado Water Pollution Control Commission had no specific water quality standards applicable to construction activities. On June 9, 1974, the State of Colorado Water Pollution Control Commission set specific standards for turbidity for both point and non-point sources. The water originating from the project area was classified B-1 and the standards required that: "Wastes of other than natural origin do not cause the turbidity of the water to be increased by more than 10 Jackson Turbidity Units or its equivalent." These standards prompted the initiation of a second phase of the water quality monitoring program which would determine turbidity concentrations on a day-to-day basis.

Water Quality Plan

Even with the monitoring program and the erosion control guidelines set forth in the Landscape and Erosion Control Manual, many water quality problems arose during the initial construction season. Surface flows from the spring snowmelt and summer thunderstorms created many erosion problems on the newly exposed soil surface, some of which went unnoticed for extended periods of time until they were brought to the attention of the Highway Department by the Forest Service or a concerned citizen. As these problems became apparent, solutions were developed and corrective action was taken. However, often the solution was too late to prevent much of the erosion and subsequent water quality degradation. The contractor was simply not aware of or prepared to handle the numerous soil erosion problems that he encountered during road construction. It was obvious, before much more construction continued, that additional project control was needed. The contractor's awareness of his responsibility for erosion and water quality control needed to be identified as much as his responsibility to build a road surface. Technical expertise in awareness of erosion-water quality problems or the development of corrective action was not readily available. To alleviate these problems, the U.S. Forest Service developed a water quality plan. Input regarding the plan was received from the U.S. Geological Survey, Water Pollution Control Commission of the State Health Department, State Highway Department, Bureau of Reclamation, Environmental Protection

Agency, Eagle and Summit County Health Departments, Colorado Division of Wildlife, and the town of Vail. In March of 1974, the Forest Service presented a draft of this Water Quality Plan to the Colorado Division of Highways. In essence, the new plan continued use of the ongoing monitoring program and use of the erosion control guidelines, but added the requirement that each project would be monitored individually, (Appendix B), and if, at any time, a water quality problem occurred, the Project Engineer and the Forest Service Liaison Officer would be notified immediately to insure corrective action was taken. A project refers to a 1-3 mile segment in the total project (17.6 miles) distance. All monitoring locations and the number of samples per day were approved by the Forest Service.

In addition, the water quality plan required the contractor to:

A. Prepare an Erosion Control/Water Quality Contingency Plan and to submit the plan for approval before beginning construction. The plan must address potential water quality problems and outline methods for correcting them. A contingency plan might include:

   1. Methods of handling groundwater seepage into the construction sites, snowmelt and rainfall runoff, and small creeks flowing through the project limits.

   2. The control of haul road or access road drainage, and delineate locations of temporary culvert installations.

   3. Locations of proposed water pollution control features, such as sediment ponds, collection ditches, pumping stations, and temporary diversion ditches.

   The contents of the contingency plan vary depending on the location of the site. Projects located in steep terrain, adjacent to streams, require a more comprehensive plan than projects on flat terrain away from the stream course.

B. Appoint an Erosion Control/Water Quality Supervisor, who is responsible for implementing control measures. Often soil erosion problems were unattended simply because no one knew whose job it was to correct the problem. By assigning the responsibility to an individual, who is held accountable, erosion control problems receive more attention.

C. List the materials, machinery, and manpower available for erosion control. Because so many erosion problems occur spontaneously, materials to control them must be on hand at the construction site. Erosion control materials might include: hay bales, culverts, irrigation pipe, sandbags, gravel, plastic, and flexible downdrains. These are discussed in detail in the following chapters.

D. Agree to give erosion control work priority over all other aspects of the construction project. When a problem is encountered, the men and materials will be released to correct the erosion/water quality problems.

After approximately nine months of negotiations, the guidelines presented in the Water Quality Plan were adopted by the Colorado Division of Highways as special provisions to the standard specifications for road construction in Colorado. They became a part of the requirements and conditions on which the contractors bid for specific construction projects (Appendix C).

EROSION CONTROL PLANNING

Many erosion and sedimentation problems can be avoided during road construction if they are anticipated and prepared for in advance. Planning ahead for these problems begins with the initial road design and continues through the actual construction period. During the Vail Highway Project, various erosion control methods were implemented and evaluated to determine their relative merit in controlling erosion and sediment problems. The following two sections discuss the permanent and temporary methods in detail and report the findings.

PERMANENT EROSION CONTROL

The design of a road is very important, for it contains the permanent features of erosion and sediment control. The topography, geology, soils, and drainage patterns of the terrain must be evaluated in order to select a road alignment that is most favorable to road construction. On Vail Pass, this was particularly challenging because the steep mountainous terrain and landslide hazard limited the options for highway location. Because the majority of the Interstate had to be located on highly erodible soils, special design considerations were included in the construction plans to overcome the erosion and sediment problems. Some of these considerations included retaining walls, protected drainage ways, sub-surface drains, contour cut-and-fill slopes to dissipate runoff, energy dissipators below concentrated runoff points and extensive buttressing below unstable land masses.

Revegetation

The primary emphasis of the revegetation program on Vail Pass was towards the control of erosion and sediment production. Specific techniques used on the highway construction were agreed upon by the Forest Service and the Colorado Division of Highways. These techniques were outlined in the Landscape and Erosion Control Manual previously mentioned. They consisted of one or a combination of the following activities: seeding with grass, fertilizer, mulching, application of protective matting, sod and the planting or transplanting of native trees and shrubs. Many of these techniques were those tested on high elevation Rocky Mountain ski areas. Revegetation techniques described in this report should be limited to slopes of 2:1 or flatter. Revegetation by itself will not stabilize oversteepened slopes, slopes with long steep faces, or slopes with drainage or seepage problems. Efforts to stabilize such slopes vegetatively without first correcting the problem will result in wasted time and money.

It is essential that revegetation proceed immediately after slope disturbance to take advantage of available soil moisture. Therefore, as cut slopes were made, revegetation closely followed the actual earth-moving process allowing a maximum of 30 ft. of continuously exposed slopes. An exception to this were fill slopes which could not effectively be stabilized during the filling operation and so other temporary erosion control techniques, as described later, were used to control sediment production from these areas. The application of the seed, fertilizer, mulch, and netting should be a continuous operation and not drawn out over a long period of time.

Topsoil

Due to the coarse textured nature of the soils, with their low nutrient and water holding capacities, topsoil was imported to cover all cut and fill slopes. The majority of the topsoil was collected from bogs and meadows, and was stockpiled on deposition areas along the right of way. Soil analysis of the topsoil is necessary to determine if the material has a suitable texture, organic matter and nutrient content.

Topsoil ready for application to a cut slope

The topsoil was spread 4-6 inches deep over the cut and fill slopes by use of a drag line. It is essential it be applied to a relatively rough slope in order to avoid possible topsoil slumping or sliding as it becomes saturated. Depths in excess of 6" are subject to sliding. There were several minor occurrences of this, but, for the most part, the topsoil operation was extremely successful.

The stockpiling of topsoil should be in areas that can be protected from erosion. Several erosion problems occurred due to the stockpiling of topsoil too close to a live drainage.

Stockpiling of topsoil too close to a live drainage without adequate protection

Seedbed Preparation

The top 4-6" should be scarified leaving a friable, moist surface for seeding. This allows for more rapid rooting of the grasses. If too long a period elapses between scarification and seeding, a hard surface crust will develop. This limits rooting depth and results in poor plant survival. It is necessary to seed immediately after soil scarification.

Seeding

Due to the differences in elevation and exposure, two seed mixtures were used in the project. The Forest Service developed the seed mixture from the best available research data and from its work on ski areas adjacent to the project. Seed species were selected that provided immediate and long term erosion control. Many of the species commonly occurred in the immediate vicinity of Vail Pass.

The initial recommendations were based on elevation using the following seed mixture:

Higher Elevations - Above 9,600 feet - Spruce, Fir, Lodgepole

Seed Variety	Percent by Weight
Slender wheatgrass	5
Meadow foxtail	20
Timothy	10
Pubescent wheatgrass	10
Smooth brome (Manchar)	25
Ladak alfalfa	25
Kentucky bluegrass	5
	100%

Lower Elevations - Below 9,600 feet - Spruce, Fir, Aspen

Seed Variety	Percent by Weight
Intermediate wheat	15
Redtop	7
Kentucky bluegrass	7
Smooth brome (Manchar)	15
Timothy	7
Red fescue	7
Meadow foxtail	7
Slender wheatgrass	15
Alsike clover	15
Ladak alfalfa	5
	100%

Since the development of the original seed mixtures, White Dutch clover, Western wheatgrass and Streambank wheatgrass have been added. In addition, the following species have been shown to be successful in other high elevation situations: Tegmar intermediate wheatgrass, Luna pubescent wheatgrass, Sherman Big Bluegrass, Potomac orchardgrass, Lutana cicer milkvetch, and Yellow sweet clover.

Initially the seed was applied at a rate of 20 lbs. per acre by broadcast and 10 lbs. per acre through drilling. This rate turned out to be somewhat low and was raised to approximately 40 lbs. per acre by broadcast seeding. A more effective way to prepare the seed mixtures might have been by indicating a dry site seed mixture and a wet site seed mixture.

Application of the seed was primarily by broadcast seeding with hand seeders. However, rangeland drills and larger broadcast seeders were also used on flatter terrain. Quality control of the seeding operation is extremely important. It is relatively easy to compute the number of seeds per square foot and to check this by the use of gummed paper during the seeding operation. It is critical that the appropriate amount of seed is being applied to the slope. Too much seed can be as bad as too little. When germination occurs, an area seeded heavily will come up in large clumps of grass and will compete heavily for moisture resulting in a dwarfed stand of grass or total dieback.

After application, the seed should be covered by one-half to one-quarter inch of soil. This can be done by dragging something over the slope or hand raking. Seed not covered with topsoil will germinate on the surface of the ground and die as the soil dries out.

In areas with common occurrence of summer rainfall, the seeding operation could take place most anytime during the summer as long as the stand of grass can be firmly established to avoid winter-kill of the young, lush grass. In drier areas with no summer rainfall, seeding should take place immediately after the snow leaves the site or late in the fall.

Fertilizer

Fertilizer is necessary for all high elevation plantings. Low nutrient levels, coupled with the short growing season, slow soil formation processes, and low decomposition rates, result in extremely harsh conditions for plant growth.

Care must be taken not to over-fertilize since it can result in water quality problems and wasted money. A given soil texture can only hold a certain quantity of nutrients. Coarse textured soils hold lower levels of nutrients than fine textured soils or soils with

high organic matter content. Therefore, it is appropriate to regulate the amount of fertilizer being applied according to the soil texture and content of organic matter. The application rate for the soils in Vail Pass was approximately 30-50 lbs. per acre of available nitrogen in the form of ammonium sulfate or urea and at least 100 lbs. of P_2O_5.

Maintenance fertilization with nitrogen is necessary to insure an adequate stand of grass. Light green or yellowing color of grass and slow growth or thinning of the stand is a good indicator that fertilization is necessary. Irrigated areas at high elevations require increased fertilizer applications due to the leaching effect of the irrigation and increased vegetation growth requiring more nutrients.

In our research on high elevation ski areas, it was found that 250 lbs. per acre of 16-20-0 ammonium phosphate sulfate should be applied with grass seeding. A follow-up fertilization of 200 lbs. per acre of 16-20-0 can be used at the beginning of the second growing season for maintenance.

Mulch

Some form of mulch is essential to aid in germination of grass seed. The mulch helps to maintain soil moisture and reduces rapid fluctuations in soil temperature. The mulch also aids in temporarily stabilizing the disturbed soil while vegetation is being established. There are many types of mulch. The primary mulch used on Vail Pass was straw applied at a rate of 1 1/2 - 2 tons per acre. It was applied by a straw blower or by hand. It is essential that the mulch be anchored to the ground to prevent its removal by wind, gravity and water. Methods of anchoring the straw include: (1) incorporating it into the soil by use of a straw crimper or modified sheep's foot, (2) spraying with a chemical tackifier, or (3) use of a netting.

On steeper slopes jute matting was used to hold the straw in place and on flatter slopes a crimper was used. Chemical tackifiers can be used on any slope, however, they were not used on this project.

Several machines are effective for crimping straw into the ground. One, made by the Finn Equipment Company, is a straight disc designed to incorporate straw into the soil by crimping or punching it into the ground. When crimping straw into the soil, the machines work better if the soil is scarified to a depth of 4-6" which is normally done when preparing the seedbed.

Application of straw by strawblower

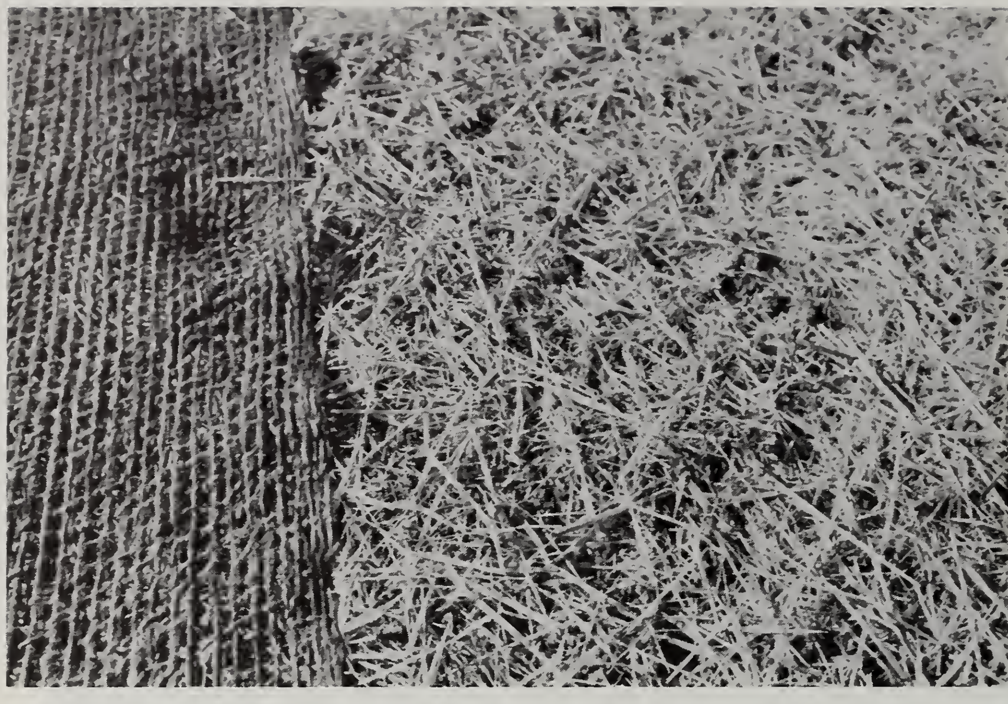
Crimping of straw

Jute Matting

Due to the highly sensitive nature of Vail Pass, it was decided that on slopes exceeding 3 to 1, some form of netting was needed to hold the straw in place. The primary netting chosen was jute matting. It is composed of heavy hemp material and comes in a roll 4' wide and 225' long. The matting was expensive but proved extremely effective in providing an immediate soil erosion protection to the sensitive soils of Vail Pass. On long slopes, however, problems occurred when jute matting was used on slopes greater than 2:1.

Jute matting being applied over topsoil, seed, fertilizer, and straw mulch

The jute matting was very effective in controlling erosion on cut and fill slopes. However, it is important that no concentrated surface runoff be allowed to flow over the slope. Runoff must be conveyed through a structure or rocklined ditch. In several locations the jute matting failed because excessive flows crossing the slope were not conveyed around the slope in a structure. Another type of failure which occurred on long slopes was the slumping of soil underneath the jute matting. This was generally caused by applying topsoil in excess of the recommended depth (4-6").



Jute matting over straw mulch

Slope failure due to soil slippage under saturated conditions

A problem developed when the jute matting was not overlapped properly. During installation there should be a 4" overlap on the matting to allow for shrinkage. Also, the jute should be adequately stapled to the ground and tucked into the slope at the upper end. One advantage of the jute over several other types of matting on the market is that if the initial seeding fails you can reseed over the jute matting while it still provides an erosion control protection. It takes approximately five years for the material to decompose at high elevations.

Stabilized slope after grass establishment

Sodding (commercially grown)

An experimental plot with commercial sod was tried on Vail Pass. Although the grass survived, there were drawbacks with planting it: (1) the cost was high and (2) watering was required for extended periods of time on a daily basis for its establishment. Because of this and the success of less expensive seeding techniques mentioned earlier, it was decided not to use commercial sod on this project. Commercial and native sodding should be limited to very sensitive areas such as stream environment zones.

Staking of the sod to the ground
was necessary to avoid slippage.

Irrigation

Irrigation was used to a limited extent on the Interstate 70 project. Several small portable irrigation systems were used, all of which were successful. Summer rainfall in the Rockies provides much of the water for stand establishment and so the need for irrigation is much less than in other areas such as the Sierra Nevada. However, in some cases, it is still essential to carry new stands of grass through dry periods. Watering is particularly important for shrubs and trees recently planted.

Water truck being used to irrigate a jute covered slope

One technique that was used for irrigation on Vail Pass was a large truck set up with spray nozzles. Care must be taken however, to use the proper size of spray nozzle. Use of too large of a nozzle may be responsible for ensuing erosion problems. For the coarse textured soils found on Vail Pass, an application of approximately 1" of water per watering was adequate. There are opportunities to irrigate while pumping water from sediment ponds and spreading it onto the slopes for filtration of suspended material.

Shrubs & Trees

Numerous shrubs and trees were transplanted from different areas in the project right of way for landscaping and long term erosion control. It was found that shrubs and trees from higher elevations could be transplanted to lower elevations; however, the reverse did not hold true. Success was very poor when plants were taken from lower elevations to higher elevations. It is also essential to maintain the integrity of the root ball with a large mass of soil and to keep the trees damp and in the shade while in storage.

Trees ready for planting; note large root ball

Some potted stock was used and it was found that a container size of one gallon or larger met with greater success than the smaller containers. Topsoil had to be added to the potting holes when planting.

Permanent Drainage

Cut and fill slopes require permanent protection from surface runoff. To insure proper location of drainage facilities, it is important to evaluate surface runoff patterns during the initial highway planning phases.

On flat gradients, rocklined ditches underlain with a porous filter blanket have been found effective for transporting water. On steeper slopes gabions underlain with a filter blanket are more effective.

Rocklined ditch used to convey water across a slope
to be covered with jute matting

Culvert outlets should be placed in a location where discharge from them can be easily routed to a natural drainage or where it can be effectively dissipated and spread over undisturbed ground.

Gabion energy dissipator at base of culvert

Energy dissipators constructed from gabions were used to dissipate water runoff below steep permanent slope drains. These structures are expensive and were installed in areas where high runoff volume and velocities were expected. When properly placed and constructed, the gabions are very effective in checking high flows; however, some problems were encountered when they were not properly placed or keyed into the slope. Soil erosion and eventual undercutting of the structure resulted from inadequate protection between the drainage outlet and the gabion structure.

Poor placement of culvert outlet and energy dissipator on a ridge resulted in erosion and possible slumping below the structure.

Undercutting of energy dissipator caused by improper placement and lack of filter blanket

Retaining Walls

Due to the close proximity of highway construction to live drainages, it was found that if fills were flattened out at 2:1, they would often encroach upon the creek. To protect the integrity of the drainages and maintain good water quality, several types of retaining walls were used. Treated wood crib retaining walls were used on small cut slopes, but the larger retaining walls were primarily precast concrete. Some walls were designed with benches so that vegetation could be planted on the steps. In addition, the concrete was dyed to match the color of the native rock and soil of the area. The retaining walls were very effective in reducing the encroachment of fill slopes on live drainages.

Wood crib retaining wall

Benched retaining wall

Permanent Bridges

All major drainages were bridged in order to provide a minimal impact on the integrity of the stream channel and to provide for wildlife movement. In many areas where fill slopes would have encroached on the stream channel, bridging was used.

Permanent bridge with minimal impact on stream course

Protection of Existing Vegetation

Protection of existing vegetation can save many dollars in revegetation work. Fencing of the vegetation during construction can prevent undue traffic and damage from equipment.

Highway Maintenance

The success of the revegetation program will depend upon highway maintenance. After construction, care must be taken not to dump spoil material over a vegetated slope. This is especially true in the spring when the drainage ditches are being cleared of sanding material and other debris. Designated dumping areas are necessary. The proper education of maintenance crews to this idea is a necessity.

TEMPORARY EROSION CONTROL

In addition to the permanent erosion control features incorporated in the roadway design, control measures must be anticipated and used during the actual construction period. These measures are temporary in nature and are designed to be removed once the construction is complete. They are extremely critical since the potential for water quality and erosion problems is most severe during and directly after construction. Temporary methods include sediment basins, sediment traps, and clear water diversions.

Sediment Basins

A sediment basin is a natural or man made depression used to detain turbid construction water runoff. Water entering the basin is slowed, allowing particulates to settle out before passing to downstream areas. The cleaner surface water is drained from the top of the basin, usually through a culvert or a rigid hose. Spillways are provided to protect the basin in the event their capacities are exceeded during storm periods. The size and amount of particulates retained in a basin are a function of the volume of inflow water with respect to the size of the basin. Generally, given a steady inflow, the larger the basin, the more sediment will be trapped.

Sediment basins are constructed by building a low head dam, excavating a depression, using a natural depression, or any combination of the three. All of these methods were used, with varying degrees of success, on the Vail Pass project. The effectiveness of the basins depended largely upon the selected design, overflow drainage, and maintenance of the structures.

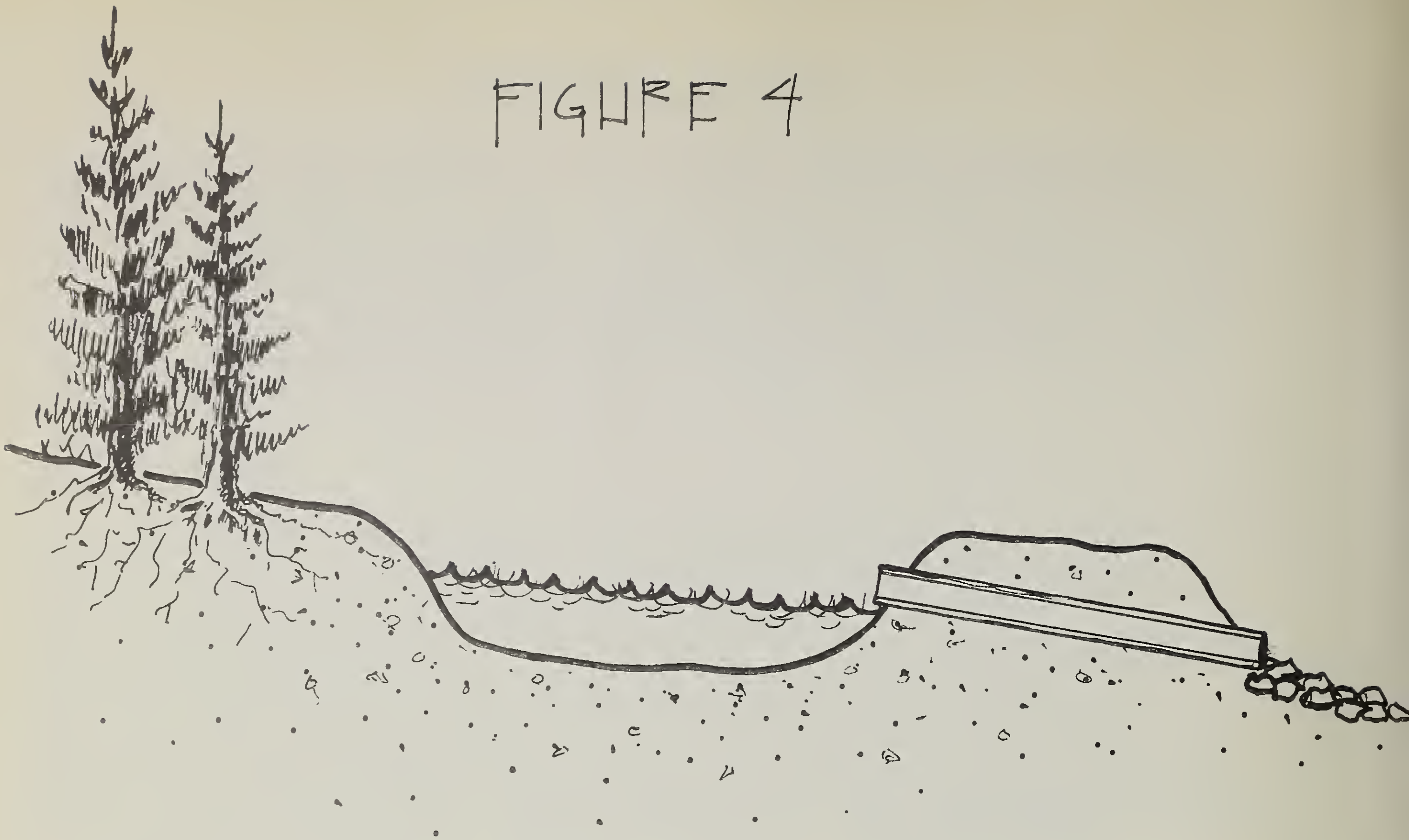
Abandoned beaver pond functioning as a sediment basin. Note irrigation system used for spreading turbid water in undisturbed areas for infiltration

FIGURE 3

PROFILE THROUGH
SEDIMENT BASIN, LOW HEAD DAM

SEDIMENT BASIN, LOW HEAD DAM

FIGURE 4



SEDIMENT BASIN, EXCAVATED DEPRESSION

Design & Placement

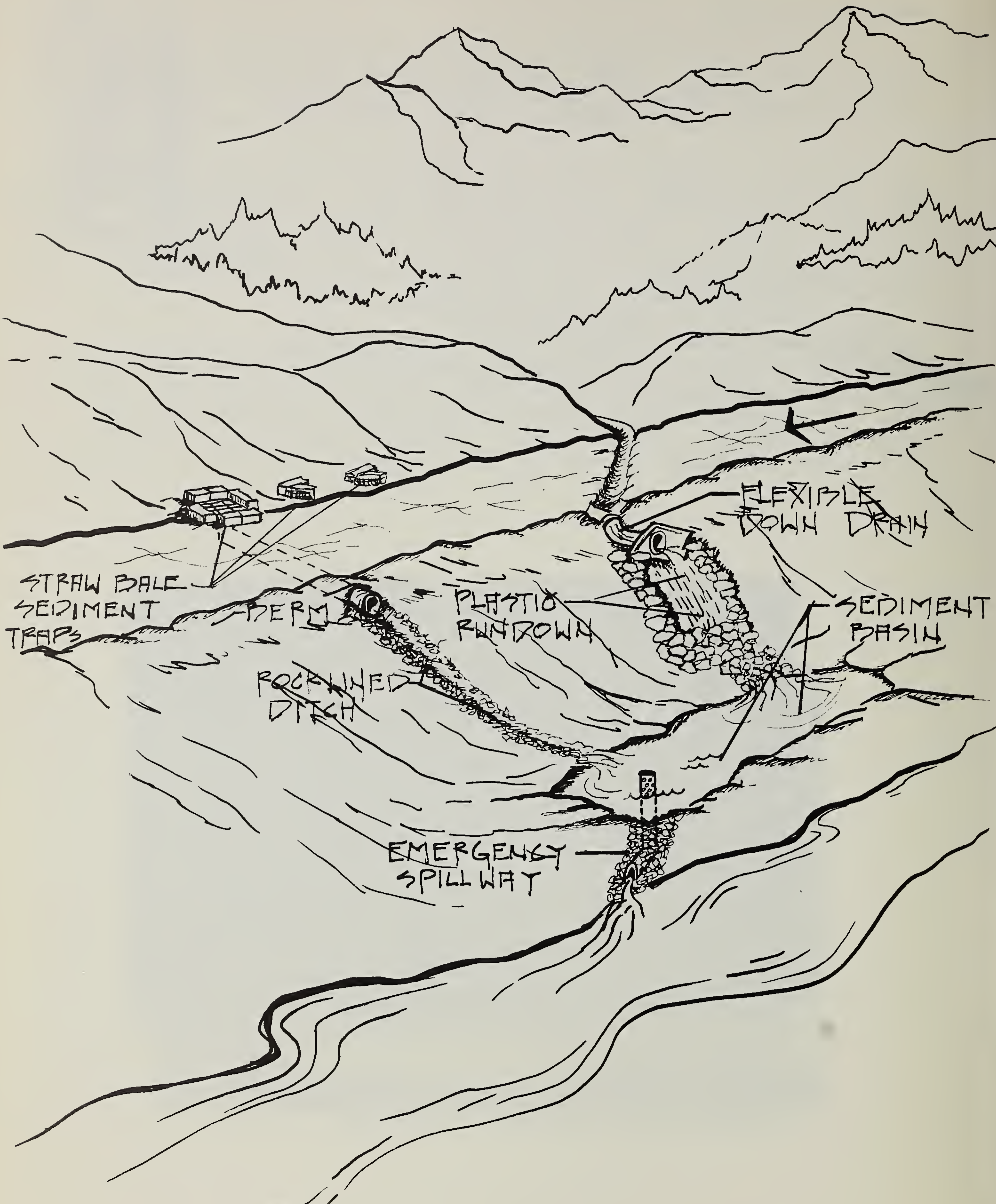
Sediment basins were difficult to construct and maintain in the steep terrain on Vail Pass. Often, the capacities of the basins were below the design water inflow because of terrain restrictions. However, the basins were effective in retaining sand and silt sized particulates.

The excavated and natural basins were located in relatively flat terrain near the valley bottoms, or on natural terraces. Construction runoff water was directed to the structures along temporary conveyances, such as berms, culverts, flexible downdrains, and plastic sheets. Overflow from the basins was discharged from a spillway to the undisturbed land or natural drainage ways below the structures.

Dam-type basins were located in small natural drainages, and usually in steeper terrain than excavated basins. The drainage bottoms were rounded out and the excavated material was used to build a low head dam. Overflow from the basins was discharged to the natural drainage below the structure through a culvert drain. Spillways made of rock or plastic were placed on the dam face for overflow protection during storm periods.

Failure of face of low head dam from inadequate compaction and subsequent saturation

FIGURE 5



SEDIMENT BASIN RUNOFF SYSTEM

Basins constructed by excavating depressions or utilizing natural depressions proved superior to ones built with low head dams. Because these basins were located in flatter terrain, access for their construction and maintenance was generally easier. Their simple design did not require the construction and upkeep of a steep dam face. In contrast, the dam-type basins were located in narrow drainages restricting the movements of the construction equipment. Often, adequate compaction was difficult to obtain, allowing the fill material to become saturated during the spring runoff and summer rains. Consequently, dam faces would occasionally fail and send large amounts of sediment to downstream areas.

Overflow Drainage

Excavated and natural sediment basins drained the cleaner surface water over spillways provided at the low end of the structure. The spillways were protected from erosion by a covering of rock or plastic. The rock size varied depending upon the source, but was usually 4 to 6 inches in diameter. Plastic coverings were 6 to 10 mils thick (1 mil = 1/1,000 inch).

Both coverings proved effective, although rock was more durable if the basin was designed for more than one season. Plastic-lined spillways were reliable, but after a year of use the plastic tended to become brittle from the sunshine (ultraviolet) and suffered tear damage. Maintenance usually involved ensuring the plastic was anchored into the soil and/or properly weighted with rock. Rock-lined spillways required very little maintenance.

Dam-type sediment basins drained by drawing surface water through a metal culvert or flexible hose. The drains are connected to a culvert at the bottom of the basin where the water is discharged to downstream areas. Different variations of these drainage devices were tried on Vail Pass, including rigid hose, soft hose, culvert, and culvert with slits.

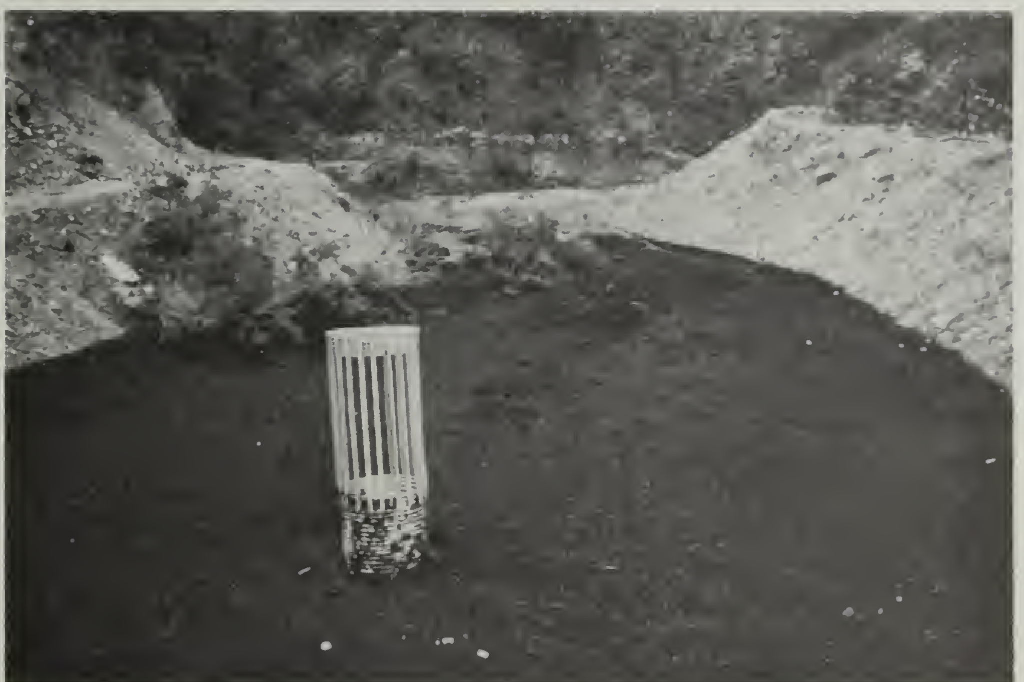
Flexible hose drains are buoyed to the basin surface by a float device, usually an airtight plastic bottle or piece of wood. These drains had continual problems in providing unrestricted drainage. The soft flexible hosing would sometimes collapse or become twisted from the movement of the float device on the basin surface. The rigid hosing also had occasional difficulty in providing good drainage. The hose was too buoyant and prevented water from entering the drain.

Culverts proved to be more effective outlet drains than the flexible hosing. The culverts, 18 to 24 inches in diameter, generally required less maintenance and were more durable than the smaller, 6 to 8 inch hose drains. Some culverts were constructed with slits in the upper

foot to provide drainage before the basin capacities (top of culvert) were reached. The Colorado Division of Highways suspended this design because the slits became plugged with sticks and other debris. Another design which has proven effective in other areas is a cage with 3 to 6 inch verticle openings designed to keep floating debris from plugging the culvert.

Flexible hose drain for sediment basins were often ineffective due to collapsing or twisting.

Narrow slits in culvert drains were not effective due to debris blockage. Note basin needs cleaning.



Wider slits in culvert drains have provided unrestricted drainage while keeping out large debris which might plug the system.

Maintenance

The effectiveness of the sediment basins depends largely upon maintenance of the structures. The basins must be drained after a runoff event to prepare for the next storm. This is accomplished by syphoning or pumping the collected clear surface water from the basin.

Sediment basins should be routinely inspected to remove debris accumulation around drainage outlets. Failure to do this can result in the drains being clogged, creating the potential to overflow or washout the basin. Provisions should be included in the Water Quality Plan to establish a maintenance schedule for the sediment basins and to designate a person responsible for the inspection.

Sediment basins should be periodically cleaned out to retain their designed trapping efficiency. Disposal sites and the equipment necessary to clean the ponds should be planned in advance. A flat or depressed area, where the sediment can be spread and revegetated, serves as a good disposal site. Depending upon the type of recovered material, it might be dried and used as fill material on the construction job. Placing the accumulated material adjacent to the basin is not acceptable. The basins on Vail Pass are of minimal size and this served to reduce the trapping efficiency because the sediment which had been trapped once, washed into the basin a second time.

Sediment Traps

Sediment traps are temporary, small detention structures that operate on the same principle as sediment basins. The traps slow the velocity of runoff water, allowing the coarser particulates to settle. The cleaner surface water is passed on to downstream areas.

Sediment traps cannot handle runoff volumes as large as sediment basins, but they are much easier and quicker to construct. They are generally used one season or less, and the accumulated sediment and the traps are removed following the construction period. The location of the traps is usually determined in the field as the need for them arises. They can be constructed from a variety of materials, including straw bales, plastic, sand bags, filter cloth, and rocks.

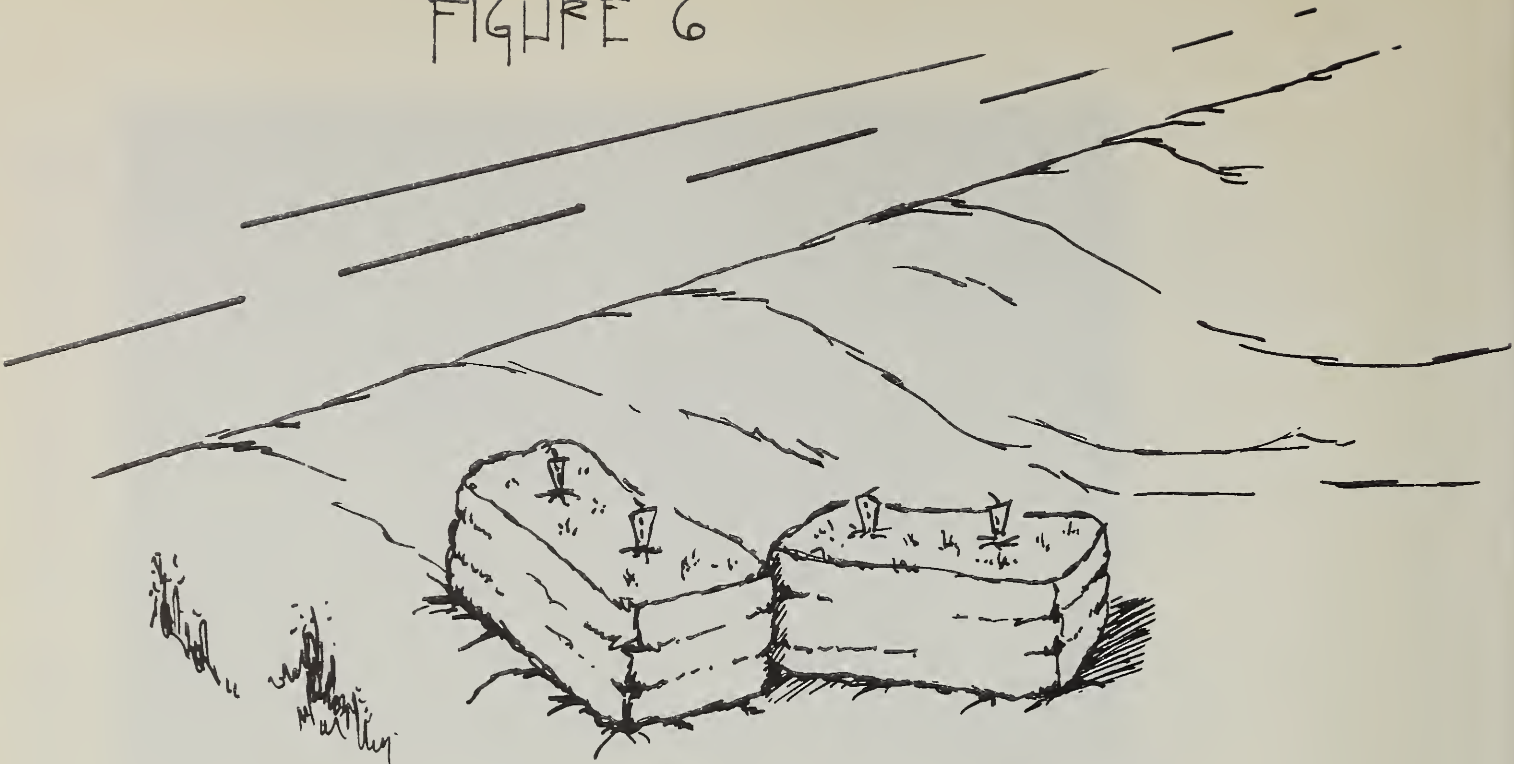
Straw bales are perhaps the quickest and easiest sediment trap to construct. Readily available and easy to transport, the bales can be formed into a sediment trap just about anywhere. They must be firmly anchored to the ground to prevent failure underneath or between the bales. The standard procedures is to key them into the ground 4 to 6 inches and to drive steel "re-bar" through the center. Anchoring the bales properly is extremely important in a mountain environment where steep gradients promote high runoff velocities. Most of the bales on Vail Pass that were not anchored failed after a short time.

Straw bale sediment trap

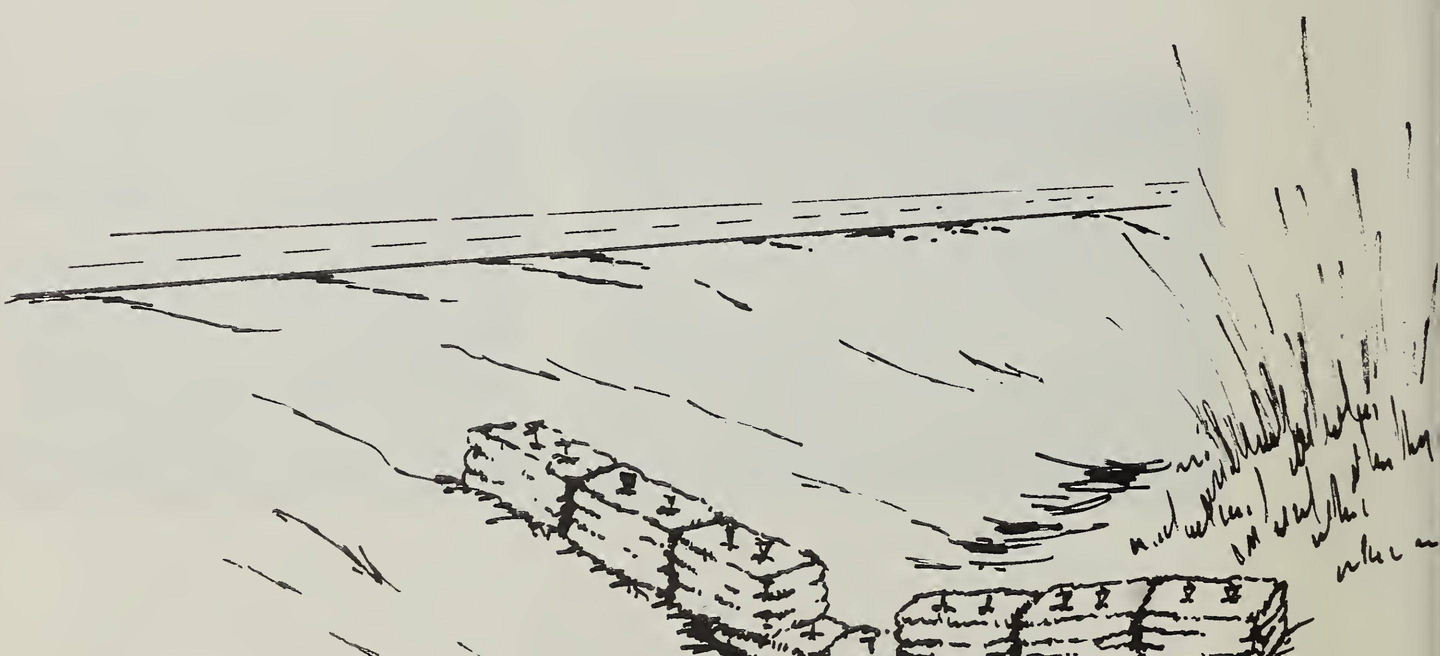
Straw bales lined with plastic are particularly effective sediment traps, especially if the bales are stacked on top of each other. The plastic prevents turbid water from seeping between or underneath the bales and keeps them drier, prolong their strength.

Straw bales lined with plastic make an effective sediment trap.

FIGURE 6

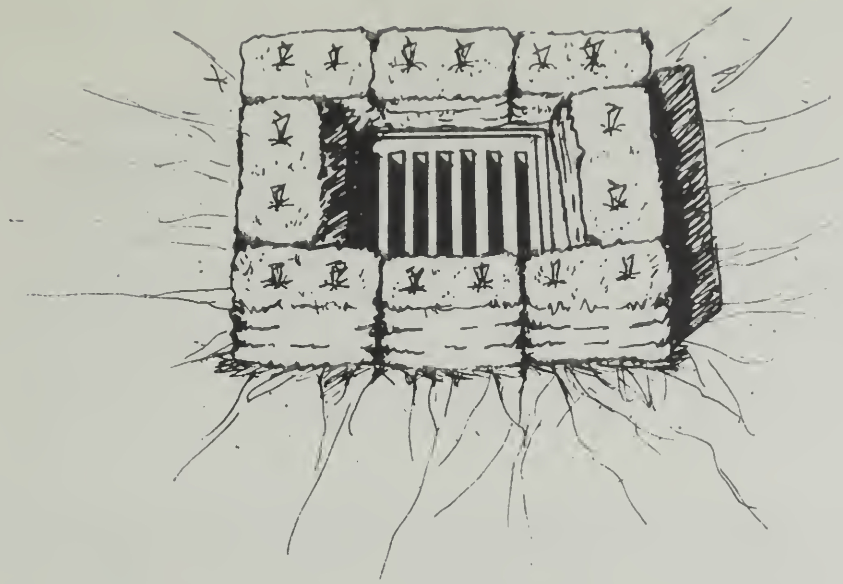


STRAW BALE SEDIMENT TRAP
IN ROADSIDE DITCH

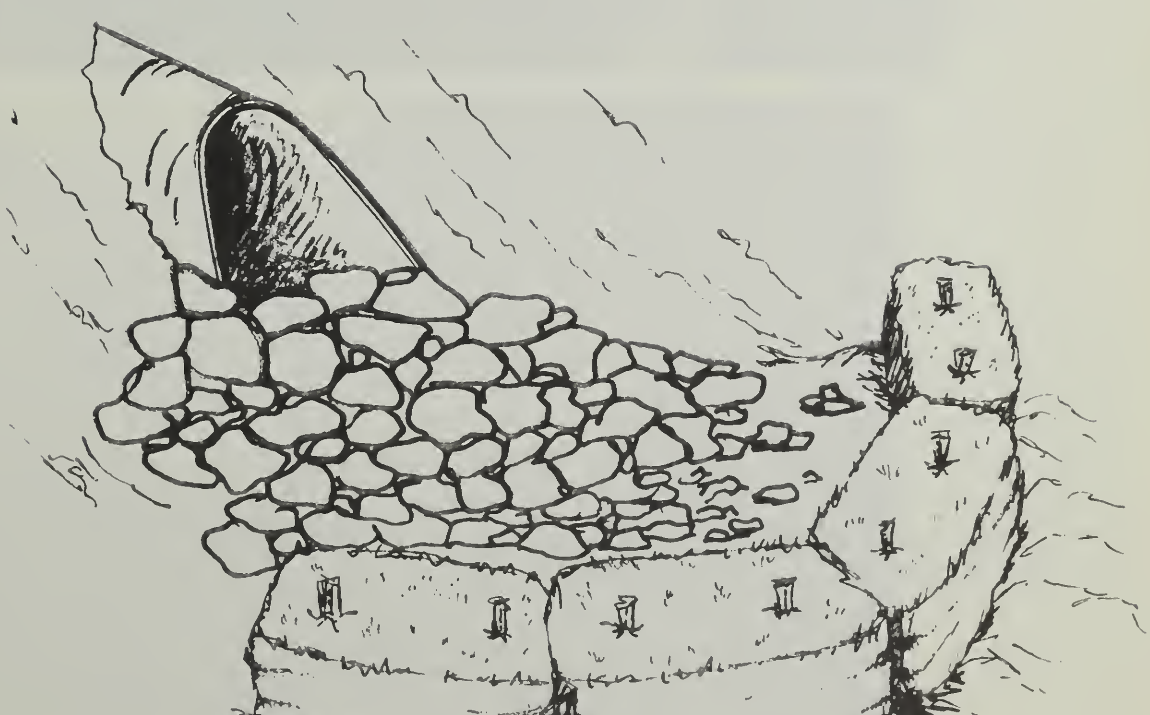


STRAW BALE SEDIMENT TRAP
IN DRAINAGE SWALE

FIGURE 7



STRAW BALE/DRAIN INLET SEDIMENT FILTER



STRAW BALE SEDIMENT TRAP AT CULVERT OUTLET

Another effective and easily transported sediment trap is constructed with the use of a fabric filter. The fabric is made from filament fibers with randomly distributed pore openings. Water easily passes through the fabric, but soil is trapped. The fabric is attached to a temporary wire fence. The bottom 6 inches of the fabric is buried in the ground to prevent water from flowing under the structure. Construction runoff water is directed to the filter trap along berms, dikes, plastic-lined ditches, or culverts. For the best results, the water should be dispersed before encountering the filter blanket. Avoid locating the fences in steep narrow drainage. The fabric has little lateral support and cannot withstand a great force such as that caused by impounding 2 to 3 feet of water.

Filter fence sediment trap

Sandbags were also effective in trapping sediment on Vail Pass. They were considerably heavier and harder to transport than straw bales, but were more durable. They worked well when encountering high runoff velocities. Although sandbags are heavy, they are pliable, allowing them to be placed on steep sideslopes and across ground surface irregularities. Because of their weight, sandbags can withstand a greater force per unit area than straw or fabric. This allows more water to be impounded with less risk of failure.

Sandbag sediment check

Small rock dams were occasionally used as sediment traps on Vail Pass. The rock size varied between 2-8" in diameter. They worked well and provided a durable structure. Rock dams must be located in accessible areas because they are usually constructed, maintained, and removed by heavy equipment. These dams were most often used in areas with an abundant rock source.

Like sediment basins, the key to success of the sediment trap is proper maintenance. In mountain areas like Vail Pass, the environment can be harsh. High winds, heavy rains, excessive runoff, and extreme temperatures can damage and reduce the effectiveness of the sediment traps. The inspection and maintenance of the structures should be performed regularly by the contractor. This should be part of the Water Quality Plan to ensure its enforcement.

Failure of sediment trap due to inadequate maintenance.

Rock check dam

Clear Water Diversion

Many erosion and sedimentation problems can be avoided if runoff water is intercepted and conveyed around disturbed construction sites. A successful clear water diversion system will intercept the clean water above the project, transport it through the work area and discharge it below with little or no water quality degradation. This not only protects the integrity of the runoff water, but also avoids on-site erosion and wet, muddy working conditions for the contractor.

Interception

Streams, springs, bogs and shallow subsurface flows all contribute water to the construction zone. In mountainous terrain these drainage patterns are complex and require an array of techniques to divert clean runoff water around disturbed construction sites. Some of the methods used on Vail Pass included shallow interception ditches, hay and plastic ditches, and small collection basins with pipe drains. Shallow interception ditches constructed above work areas were effective in routing clean water around the projects. The ditches were constructed on the

contour and most often used on north aspect slopes where numerous springs and wet subsurface conditions existed. The diverted water was routed to natural drainageways or culverts to convey it below the work zone. The ditches were either hand dug or trenched with a small backhoe.

Hand dug ditches proved superior to backhoe trenches. The ditches were usually constructed on side slopes during the early construction season when conditions were wet. Backhoes had a difficult time operating in these conditions, often sliding and rutting the area adjacent the ditch. They also had a disadvantage in working in and around obstacles such as rocks and trees. Hand dug ditches, on the other hand, created minimum impacts and could be constructed through tight places such as forested hillsides.

Hand dug ditch intercepting clear water above project area

Construction of clear water diversion by backhoe
resulting in unnecessary disturbance

Once constructed, the ditches held up well. Minor slumping and vegetative overgrowth were evident after one year of use. A jute netting or similar product should line the ditch at gradients over 6% to safeguard against erosion. Drainage was most efficient when gradients ranged from 5 to 8 percent. Less than that, water ponded and drainage was ineffective. Gradients over 10% that were not lined with a jute netting caused some scour and minor erosion.

Hand dug diversion should be lined
with jute at gradients over 6%

Another less effective method of diverting water along the contour was the use of straw bales lined with plastic. Surface flow coming in contact with the hay and plastic was diverted laterally to a natural drainage or culvert. Both the straw bales and plastic were keyed 4 to 6 inches into the ground.

This diversion system was expensive to construct and required continual maintenance. The plastic and straw were difficult to keep anchored in the ground and the plastic was subject to tear damage from wind, rocks and tree limbs. It was also limited to diverting surface flows and did not reach the shallow subsurface water. It is recommended this system be discouraged in favor of the hand dug ditches.

Straw bale diversions covered with plastic deteriorated after short period of use

Collection basins were effective in impounding and diverting water where drainage problems were isolated to a few places such as a spring, seep or small creek. Small basins were dug in the ground or constructed with sandbags at the water source. The impounded water was diverted into irrigation pipe, culvert or flexible plastic down drains and directed through the work area. The water was then discharged into natural drainage courses below the construction site.

Collection basins work well if they are inspected and maintained. Debris must be kept free from the inflow pipe to prevent overtopping and subsequent erosion. As in the case of other temporary erosion control structures, a routine maintenance schedule is imperative and should be specified in the Water Quality Plan.

Transport

Once the clean water is diverted above the construction sites either by ditches or basins, the water has to be directed safely through the construction zone. Many different methods were used on Vail Pass including metal culverts, flexible plastic down drains, irrigation pipe and plastic lined ditches. The method of transport depended upon the anticipated water volumes, the duration of use, length, and steepness of transport.

Metal culverts 18-24 inches in diameter were the most effective all around method of transporting water through work areas. They can withstand high runoff velocities, transport water great distances, and can be expected to hold up more than one construction season. Their disadvantage is that metal culvert is more expensive than some of the other diversion materials.

Culvert transporting clear water through work area

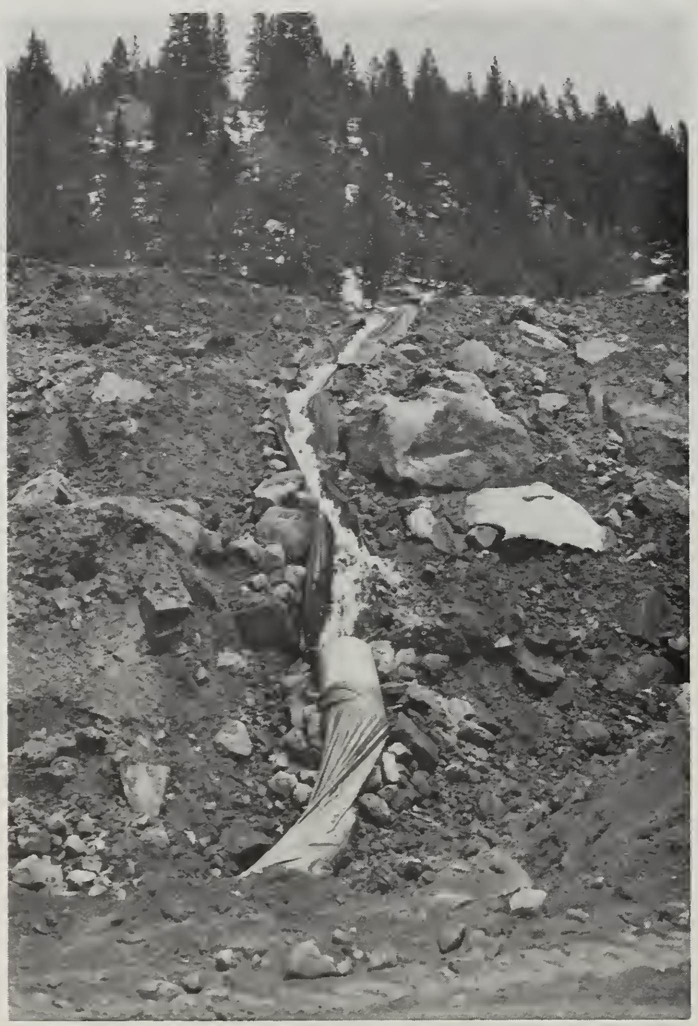
Irrigation pipe also worked well as a water transport, but because of its size (8 inches diameter), was restricted to intercepting small quantities of water. Also, the water intake opening required more maintenance to remove debris accumulations. During late fall and early spring operation, ice accumulations would sometimes plug pipe inlets and restrict drainage. Someone must be on hand to chop and remove the ice for it to remain functional. This type of drain should be used only during the summer and should not be counted on to transport spring runoff water.

Flexible down drains and plastic lined ditches are also reliable water transports provided they don't have to carry great runoff volumes over long distances. These structures are more temporary than the metal pipes and require more maintenance.

Flexible down drains are excellent on short, steep slopes. The flexibility conforms to the water flow, maximizing friction and slowing the water velocities. The drains should be staked to the ground to prevent excessive movement from wind or internal water flow. The movement may cause creases or bends which can fail under force of the drainage water.

Flexible down drains used for temporary protection of disturbed areas

Fill slope failure from inadequate maintenance of
flexible down drain



Plastic lined ditches must be inspected
and maintained regularly to avoid failure

The use of plastic lined ditches should be limited to short duration diversion projects. The ditches require constant inspection and maintenance. The plastic is anchored in place using logs, rocks, stakes or other means. Failures occurred when the plastic slipped beneath the weight, spilling drainage water on the disturbed soil. The plastic must also be durable so water flow does not tear it on the irregular channel bottom. The plastic should be at least 6 mils and preferably 10 mils thick.

Water Discharge

Discharging the intercepted water below the work area is the final stage of a water interception system. In the steep terrain on Vail Pass, energy dissipators were often required below the drains to slow the runoff water to non-erosive velocities. A variety of temporary dissipators were used on the pass including loose rock riprap, straw bales, and silt fences.

Water discharged from a clear water diversion onto a disturbed slope resulted in serious gullying. Water should be carried through the project area in the diversion and discharged into an energy dissipator.

The incomplete diversion system in the previous photograph, routed water onto a disturbed slope which resulted in serious gullying. A complete system carries the water through the project area and discharges it into an energy dissipator.

Loose rock riprap or a wire and rock mattress placed below a drainage outlet can effectively check erosion and undercutting. Loose riprap should be graded angular rocks, 4-10 inches in diameter. The rock protection should extend to and around the drain outlet. The riprap should be at least 4 feet wide to prevent drainage from circumventing the structure.

When water discharge is temporary due to construction activities, simple and less expensive energy dissipators are adequate. Straw bales keyed into the ground and lined with plastic were commonly used on Vail Pass. Maintenance was required to see that high velocities did not tear the plastic and break the straw bales. A silt fence (as described earlier) was placed in a semi-circle behind the straw bales to retain sediment that was picked up during transport. These dissipators worked well providing high runoff volumes were not encountered. The straw and plastic were most often used below 8 inch irrigation pipe drains but were not used below 18 to 24 inch culverts. Energy dissipators below high discharge drains should be made of rock even if they are temporary.

Straw bales lined with plastic effectively dissipate high velocity runoff below an irrigation pipe drain. A silt fence placed behind the dissipator retains any sediment picked up during transport.

Temporary Roads

Numerous temporary roads were required for the project during the early construction phases. Proper location of these roads can eliminate many potential water quality problems. Where possible, roads should avoid streamside zones, potential landslide areas and steep terrain.

Adequate drainage in the form of well spaced water bars, culverts and temporary bridges can effectively reduce water quality problems during their use.

Upon completion of use, the roads should be water barred, seeded, fertilized, mulched and closed to access. This should be followed by field inspection to insure the site was properly revegetated and had waterbars properly installed.

Temporary Stream Crossings

Due to the steep, dissected terrain on Vail Pass, numerous temporary stream crossings were required during construction. Temporary bridges, culverts and low water crossings were used. The selected design depended upon the type of equipment crossing the stream, the number of crossings required and the duration of use.

Temporary bridges and culverts were installed in locations where heavy traffic was anticipated over an extended period. The temporary bridges were judged to be the best method for protection of water quality. Very little fill material encroached into the stream channel and once in place, log cribbing prevented the soil from sloughing into the water. Their disadvantage was they were expensive to install and deteriorated somewhat under heavy use. In contrast, culvert crossings held up well once constructed. However, disturbance of fill material during their installation and removal caused localized stream sedimentation.

Temporary bridges were built at stream crossings where heavy traffic was anticipated. Note culvert discharging turbid construction runoff into sediment basin.

Low water crossings were originally permitted in a few locations where light equipment needed to cross the stream only once or twice. However, excessive disturbance due to saturated soils and absence of rock material adjacent the streams prompted later elimination of this method. Small temporary bridges were used in their place.

Low water crossings were eliminated due to soil erosion and subsequent water quality degradation.

Small temporary log bridges pose a minimal impact on the stream channel.

SUMMARY

Many erosion and sedimentation problems can be avoided during road construction if they are anticipated and prepared for in advance. Planning ahead for these problems begins with the initial road design and continues through the actual construction period. The preparation of an erosion control/water quality contingency plan prior to construction activity is essential to protect the soil and water resource.

Many new and innovative erosion control techniques were implemented during construction of I-70 Vail Pass, Colorado. The following summarizes those measures that worked well in the high elevation mountain environment. They can be applied to other land disturbing activities including: timber sales, mining operations, ski areas, and all construction sites.

Permanent Erosion Control

Revegetation

1. Begin revegetation within 10 days of site disturbance.
2. Maximum unprotected distance on cut slopes is 30 ft.
3. For best revegetation results, keep slopes to 2:1 or less.

Topsoil

1. Apply topsoil to a depth of 4-6".
2. Apply topsoil to a rough slope.
3. Stockpile topsoil away from drainages.
4. Analyze topsoil for texture, organic matter, content and nutrient levels to determine adequacy for revegetation.

Seedbed Preparation

1. Scarify the top 4-6" of soil before seeding.

Seeding

1. Broadcast seed at a rate of 40 lbs. per acre.
2. Design grass seed mixture for conditions encountered.
3. Add innoculated legumes to seed mixture to fix nitrogen.
4. Cover seed with approximately 1/2 to 1/4 inch of soil.
5. Field check seed application rates.
6. If summer rainfall is plentiful, seed early enough in the season so that the grass can become established prior to winter.
7. If summer rainfall is scarce, and irrigation is not used, seed in late fall or early spring .

Fertilizer

1. Base fertilizer rates on soil texture.
2. Fertilize grass with quick release fertilizer such as 16-20-0 ammonium phosphate.
3. Maintenance fertilizing of grass is necessary in the spring for several years.
4. Irrigated areas need fertilizing more often.
5. Fertilize shrubs with slow release pelletized fertilizer.
6. Fertilizer pellets should not come in contact with shrubs or tree root mass when planting.

Mulch

1. Straw mulch should be applied at a rate of 1 1/2 tons per acre.
2. Application of straw by straw blower is more cost effective and provides more even coverage than hand spreading.
3. All mulch, regardless of type used, should be anchored in place.
4. Straw mulch on flatter slopes can be anchored by crimping.
5. Straw mulch on steeper slopes can be anchored by tackifiers or nettings.

Jute Matting

1. Jute matting has proven to be an effective material for anchoring straw in place on all slopes 2:1 or less and short steeper slopes.
2. Overlap edges of jute matting 4 inches and anchor upper and lower ends by burying.

Sodding

1. Commercial sodding should be limited to sensitive areas such as stream environment zones.
2. Sod should be staked in place.
3. Sod should be irrigated daily during initial establishment.

Irrigation

1. Irrigation may be necessary to carry trees, shrubs and grass through dry periods.
2. Full time maintenance of irrigation systems is necessary.
3. Water trucks fitted with spray nozzles are effective for irrigation.
4. Avoid concentrating large amounts of water on a slope such as from too large a nozzle, or from excessive watering.
5. Commercial aluminum irrigation systems are effective.

Shrubs and Trees

1. Transplant material from the same general elevation and area.
2. Maintain the integrity of the root ball.
3. Keep material damp and in the shade while in storage.
4. For potted stock, use containers of one gallon or larger for the best survival, particularly if irrigation is not available.
5. Add topsoil to potting holes.

B. Permanent Drainge

1. Protect all cut and fill slopes from surface runoff.
2. All drainage channels should be lined. The type of lining will depend upon volumes of flow and the gradient of the ditch.
3. Energy dissipators are necessary at the outlet of all drainage facilities.
4. Locate the outlets of drainage facilities where water can be effectively dissipated and conveyed to a natural drainage or can be effectively dispersed.
5. Properly constructed and placed gabion energy dissipators are effective.

C. Retaining Walls

1. Retaining walls are effective in reducing encroachment of fill slopes on live drainages.

D. Permanent Bridges

1. Bridges are effective in reducing encroachment on live drainages providing for wildlife movement and protecting stream environment zones.

E. Protection of Vegetation

1. Protection of existing vegetation can save many dollars in revegetation.
2. Fencing existing vegetation during construction is an effective protective mechanism.

F. Highway Maintenance

1. Highway maintenance should be oriented towards maintaining and protecting vegetated areas.
2. Designated dumping areas for ditch debris is a necessity.

Temporary Erosion Control

A. Sediment Basins

1. In steep mountainous terrain, excavated and natural sediment basins are preferred over low head dams. Easier access, reduced maintenance and infrequent failure are the primary reasons.

2. Provide protection to emergency spillways on all basins to prevent erosion damage if capacities are exceeded during a storm event. Rock and plastic linings have both worked well, however, rock is preferred if the basin is to be used for more than one construction season.

3. Culvert drains, 18-24" in diameter, have proven to be more effective outlet drains than flexible hosing. They require less maintenance, are more durable, and have greater drainage capacities.

4. The effectiveness of the sediment basins depends upon their maintenance. Routine inspection and maintenance is mandatory.

B. Sediment Traps

1. Sediment traps constructed of straw bales, plastic, sandbags, filter cloth and rocks have all worked with success. The key to their success is proper installation and maintenance.

2. The selected sediment trap design is dependent upon the type of expected construction runoff. The following matrix serves as a general guide for design selection.

Sediment Trap Design

1 preferred — 3 — 5 least preferred

-- design not applicable

Criteria \ Design	straw bales	straw bales lined with plastic	sandbags	rocks	filter cloth
Ease of construction	1	2	5	3	4
Least maintenance	4	5	2	1	3
Least expense (includes labor)	1	2	5	4	3
High runoff velocities (concentrated flow)	--	3	1	2	--
Moderate runoff velocities (dispersed flow)	2	3	--	--	--

C. Clear Water Diversion

1. A successful clear water diversion system will intercept the clean water above the project, transport it through the work area and discharge it below with little or no water quality degradation.

2. Hand-dug interception ditches are preferred over backhoe trenches and straw bales lined with plastic. Backhoes rut and disturb areas adjacent the ditch, while the plastic and straw systems suffer tear damage from wind, rocks and tree limbs.

3. Drainage of the interception ditches was most efficient when gradients ranged from 5 to 8 percent.

4. The effectiveness of the water transport through the work area depends largely upon proper design and maintenance. The following matrix is a general guide for selecting a transport design.

Water Transport Design

x = acceptable design　　　　o = not acceptable design

Criteria / Design	Culvert	Flexible downdrains	Irrigation pipe	Plastic lined ditch
High water volumes	x	o	x	o
Low-moderate water volumes	x	x	x	x
Expected use less than one year	x	x	x	x
Expected use more than one year	x	o	x	o
Transport less than 50 yards	x	x	x	x
Transport more than 50 yards	x	o	x	o
Transport down short steep slopes	x	x	x	o
Transport down long steep slopes	x	o	x	o

5. Loose rock riprap placed below the diversion drainage outlet will prevent erosion. Riprap should be graded, angular rock, 4-10 inches in diameter.

6. Straw bales lined with plastic are effective energy dissipators when high runoff volumes are not encountered.

D. Temporary Roads

1. To avoid potential water quality problems, temporary roads should not be placed in streamside zones, potential landslide areas and steep terrain.

2. Properly spaced and placed water bars should be installed before the road is used.

3. After use, roads should be revegetated and closed to access.

E. Temporary Stream Crossings

1. Prohibit low water crossings where streamside soils are saturated and little rock protection exists adjacent the stream.

2. Construct temporary bridge or culvert crossings in locations where heavy traffic is anticipated over an extended period.

APPENDIX A

Water Quality Stipulations for Vail Pass Project

I 70-2(48)
Bighorn to Timber Creek

STATE DEPARTMENT OF HIGHWAYS

CHAS. E. SHUMATE • EXECUTIVE DIRECTOR

STATE OF COLORADO

ION OF HIGHWAYS
HAASE
ENGINEER

COLORADO STATE PATROL
COL. C. WAYNE KEITH,
CHIEF

4201 EAST ARKANSAS AVENUE • DENVER, COLORADO 80222 • (303) 757-9011

May 23, 1975

File: 09-01-01.3

MAY 27 '75
ENGINEERING

Mr. W. J. Lucas, Regional Forester
United States Department of Agriculture,
Forest Service
11177 West Eighth Avenue, Box 25127
Lakewood, Colorado 80225

Dear Mr. Lucas:

Here, for your use and file, is a fully executed copy of Stipulations for Projects I 70-2(48), I 70-2(49), I 70-2(52), I 70-2(53) and I 70-2(54) as requested in your letter of May 9, 1975.

Very truly yours,

CHAS. E. SHUMATE
Executive Director

By E. N. Haase
E. N. HAASE
Chief Engineer

ENH/cs
Encl.
cc: R. A. Prosence
R. E. Heathcote
Vernon/Kasenga
M. R. Harrison

File: SHUMATE-HAASE-CAPRON-COX

STIPULATION

This Stipulation, msde this 9th day of May, 1975, by and between the Department of Highwsys, State of Colorado, hereinafter referred to as the State, and the Forest Service, United States Department of Agriculture, acting herein by and through the Regional Forester, hereinafter referred to as the Regional Forester.

WHEREAS, the State is engaged in the laying out, construction, operation, and maintenance of a public highway designated as Projects I 70-2(48), I 70-2(54), I 70-2(49), I 70-2(53), and I 70-2(52) which traverse lands of the United States in the State of Colorado, Counties of Eagle and Summit, administered by the Forest Service, and

WHEREAS, the State and the Regional Forester desire to cooperate in the development and construction of a highway which will adequately protect and afford utilization of the lands of the United States traversed by the highway for the purposes for which the lands are being administered.

NOW THEREFORE, supplementary to the terms and conditions of the highway easement deed between the United States, acting through the Department of Transportation, Federal Highway Administration, and the State, the parties hereto agree to carry out the following provisions during the construction stage (Construction stage to begin when construction activities commence on lands administered by the Forest Service and end when the Regional Forester and the State mutually agree that any work done thereafter will be considered as maintensnce, EXCEPT, that the Regional Forester reserves the right to reinstate the provisions of this stipulation if the State subsequently submits plans for reconstruction or alteration of the highway).

The State will:

1. Comply with the following recommendations of the Colorado Division of Wildlife and the Forest Service for wildlife and fish management.

   a. Take all necessary precautions to avoid damage to fish habitst and exercise every reasonable precaution to prevent muddying or silting of live streams. For the purpose of these stipulations, Bighorn, Gore, Black Gore, Timber, Wilder, Smith, Stafford, Culler, and West Tenmile Creeks shall be considered live streams.

   b. Not deposit material removed from the roadway or channel changes in live streams or into the streams or stream channel where it would be washed away by high stream flows.

   c. Not haul materials, including logs, brush, and debris by fording live streams, but will provide temporary bridges or other structures for this purpose.

d. Not operate mechanized equipment in live streams, except as may be required to construct bridges, retaining walls, or channel changes as stipulated.

e. Not allow oil or greasy substances originating from construction operations to enter or be placed where they may later enter a live stream.

f. Permit no construction activity within twenty-five (25) feet from the edge of major paralleling streams, namely: Gore, Black Gore, and West Tenmile Creeks. The only exceptions will be where such activity is indicated in the approved plans and specifications, or has the advance approval in writing from the Forest Supervisor.

g. Continue in effect the Cooperative Agreement with the U. S. Geological Survey for the operation of the three water quality monitoring stations for the collection of hydrologic data. The three stations are located on Gore, Black Gore, and West Tenmile Creeks.

2. Dispose of waste material resulting from slides during and after construction and surplus material at locations approved by the Forest Supervisor. A plan showing the proposed method of disposal shall be submitted at the time approval is requested.

3. Treat sections of existing road, to be abandoned as a result of the proposed new construction, as designated by the Forest Supervisor to restore them to their natural state. The necessary treatment will be determined during a joint review between the Forest Service and the State and may include ripping of roadbed, removal of drainage structure, and opening drainage channels. Plans and specifications as mutually deemed appropriate to accomplish the objective will become a part of this stipulation.

4. Provide standard highway signs to identify the following locations:

a. On Project I 70-2(49) near Station 432 (EBL).
Install WHITE RIVER NATIONAL FOREST boundary sign.

5. Permanently monument the right-of-way prior to the completion of construction in accordance with State requirements for such right-of-way but in any event, the minimum requirements will be to place permanent monuments at the intersection of right-of-way with all property lines, section lines, and at intervals of not more than 1,000 feet along the right-of-way limits. Much of the area traversed by the projects involved has not been officially surveyed and the requirement for monumenting the intersection of the right-of-way with section lines is waived by the Regional Forester where section lines have not been established.

~~H.~~ 6. Reestablish or restore public land monuments disturbed or destroyed by construction, reconstruction, or maintenance according to instructions of the Bureau of Land Management, Department of the Interior. Other land monuments and property corners or witness markers shall not be damaged, destroyed, or obliterated without the prior permission of the Regional Forester and shall be relocated or reestablished in accordance with standards satisfactory to the Regional Forester.

IN WITNESS WHEREOF, the parties hereto have caused this Stipulation to be executed on the day and year first above written.

STATE
DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS
STATE OF COLORADO

E. N. Haase

By ____________________

Title Chief Engineer

George W. Fauntleroy
Acting Regional Forester
United States Forest Service

APPENDIX B

Water Quality Monitoring Program

WATER QUALITY MONITORING

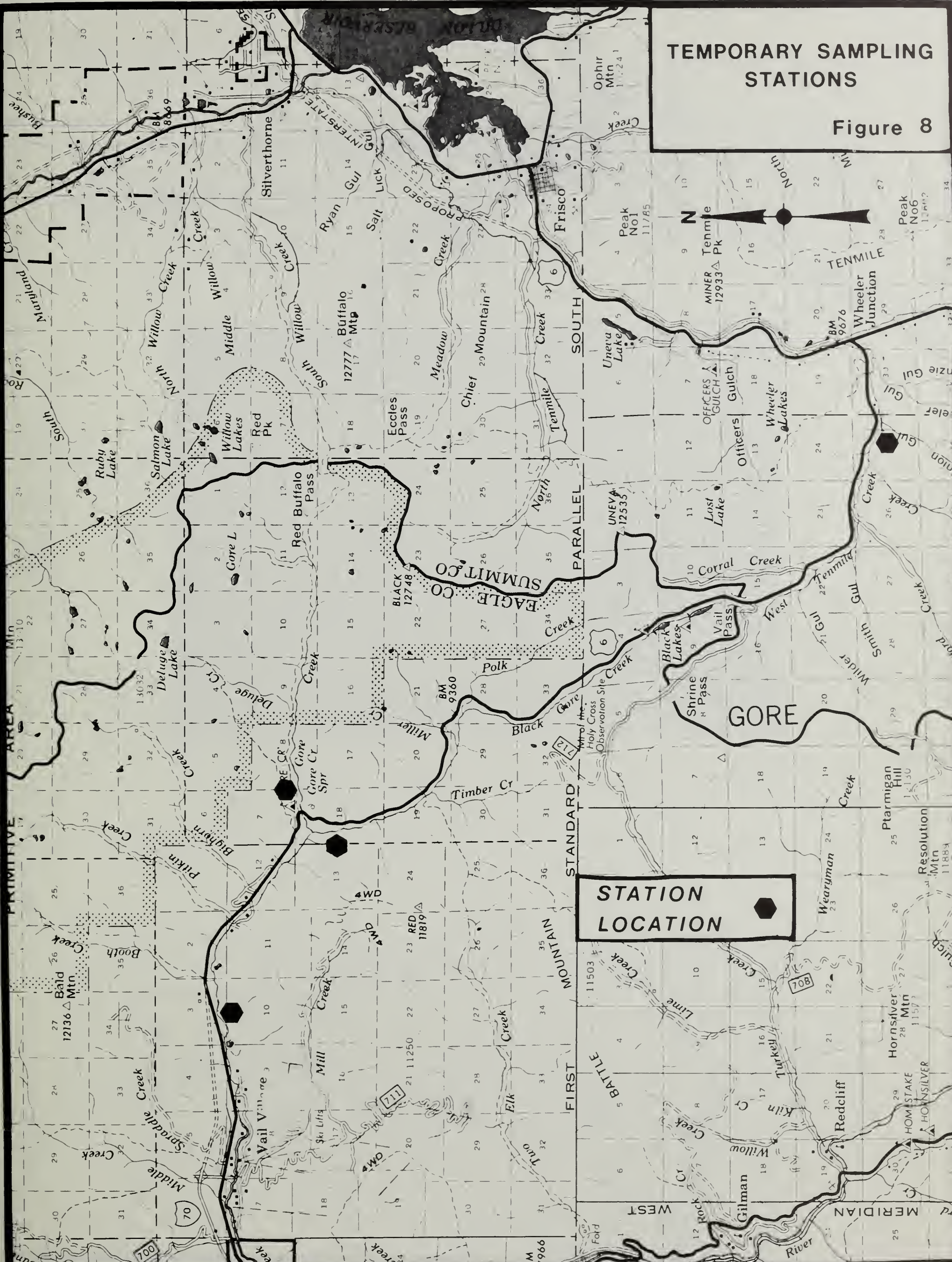
To determine the effectiveness of the discussed erosion control measures, a two part sampling program evolved. Initially, the sampling program was set up as a requirement of the Forest Service in the Environmental Analysis Report. It was further recommended that all water quality data be collected by a third party. The U. S. Geological Survey later became that third party and financed the program with the Colorado Division of Highways on a matching fund basis.

USGS Monitoring Program - Phase I

Due to a time lag in setting up contractual arrangements between the Colorado Division of Highways and the USGS, initial baseline data was collected by Water and Environment Consultants, Inc. Temporary stations were set up and samples were taken at the four locations indicated in figure 8. Discharge was recorded and twice daily sediment samples were collected on a monthly basis for the parameters described under the USGS program.

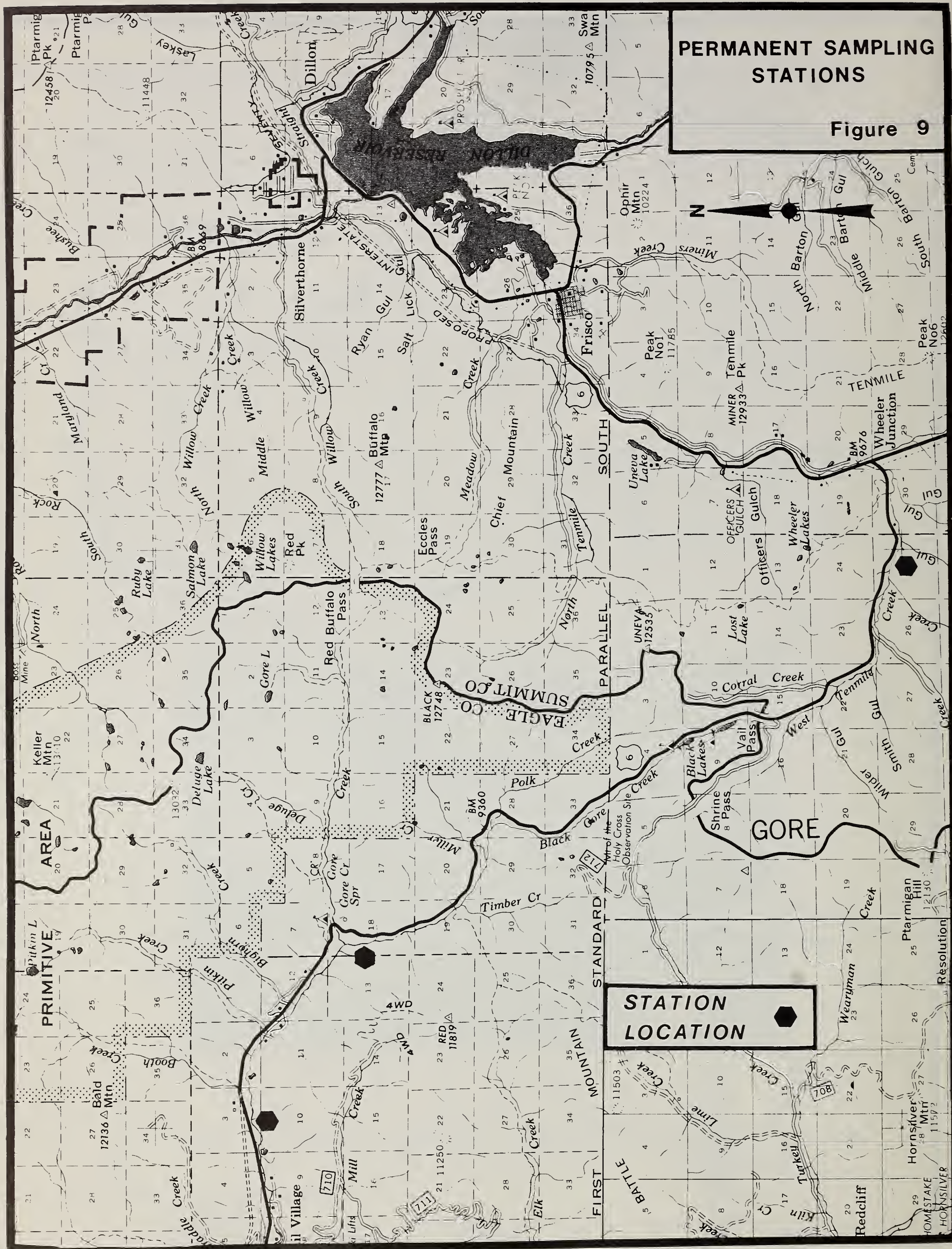
Later, permanent stations were built by the USGS and equipment was installed at three of the four original locations indicated in figure 9. (The station at Gore Creek Campground became an undisturbed site and was abandoned as a sampling station.) At each site a small building was constructed which housed a manometer-servo stream gauge, and an automatic sediment sampler.

Manometer-servo Water Level Sensor
A-35 Recorder in Background



TEMPORARY SAMPLING STATIONS

Figure 8



PERMANENT SAMPLING STATIONS

Figure 9

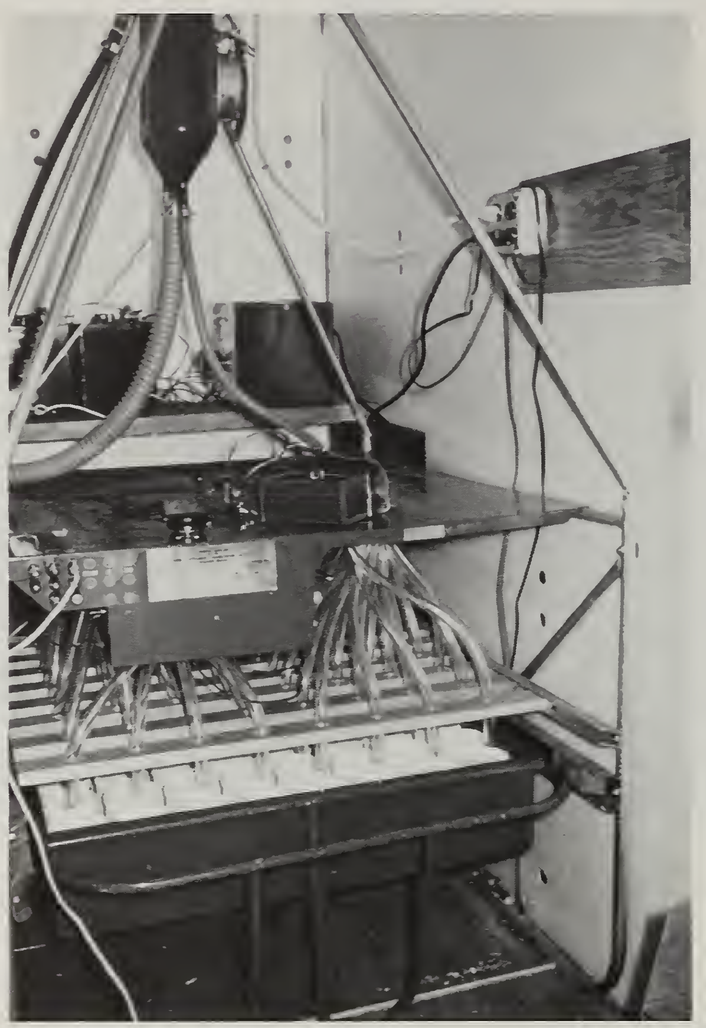
USGS Monitoring Program - Phase II

As was mentioned before, the State of Colorado Water Pollution Control Commission set specific standards for turbidity after initial implementation of the project. As a result, at each of the three automatic sediment sampling stations, a Hach Flow Through Surface Scatter 3 Turbidimeter was installed. In addition to this, each turbidimeter was tied-in with a recorder. The electrical system of this turbidimeter was set to

In-line Surface Scatter Turbidimeter

trigger the automatic sediment sampler when the turbidity reached a set level. The sediment sampler would then continue sampling on a 15 minute basis until turbidity returned to the set level.

Each sediment sampler has the capability of collecting up to 72 samples before servicing is required. The sampler can be set by a clock or can be activated by a rise or fall in stream flow. The samplers collected samples twice daily during runoff periods and during construction activities, and once daily during the winter months.



Automatic sediment sampler

In addition to this, chemical samples were taken monthly for analysis of the following parameters: temperature, specific conductance, dissolved oxygen, pH, carbon dioxide, alkalinity, bicarbonate, carbonate, dissolved nitrate plus nitrite, dissolved ortho phosphate, dissolved ortho phosphorus, hardness, non-carbonate hardness, dissolved calcium, dissolved magnesium, dissolve sodium, sodium absorption ratio, percent sodium, dissolved potassium, dissolved chloride, dissolved sulfate, dissolved fluoride, dissolved silica, dissolved iron, dissolved manganese, and dissolved solids.

USGS Monitoring Program - Individual Project Monitoring

Turbidity was monitored on each project as a part of the requirements specified in the water quality plan. All samples collected were analyzed on a Hach 2100A Turbidimeter. Samples were collected with a DH48 sediment sampler above and below all projects. The number of samples were primarily dependent upon the relative threat of pollution. Visual observations were also a part of the monitoring program which was carried out by the Colorado Division of Highways.

DH-48 Sediment Sampler used for the collection of samples above and below each project on Vail Pass as specified in the Water Quality Plan.

Hach 2100A Turbidimeter used for analysis of hand collected samples to determine compliance with State Water Quality Standards.

APPENDIX C

Water Quality Plan & Letter of Assurance

WATER QUALITY PLAN

COLORADO PROJECT NO. I 70-2(53)192

TEMPORARY WATER POLLUTION CONTROL provisions in subsection 107.23 the Standard Specifications are hereby deleted. The following provisions shall apply:

IPORARY WATER POLLUTION CONTROL

) DESCRIPTION. This work shall consist of temporary measures needed to control water pollution. These temporary measures shall include berms, dikes, dams, sediment basins, fiber mats, netting, gravel, mulches, grasses, slope drains and other erosion control devices or methods. These temporary measures shall be installed at the locations where needed to control erosion and water pollution during the construction of this project, and as directed.

Temporary pollution controls shall be coordinated with the permanent erosion control features specified elsewhere in the contract to the extent practical.

The Contractor shall control his operation in such a manner that drainage from the area of his activities will not cause the water quality of the principal drainage, Black Gore Creek, (Classified B-1) to exceed the permitted limits of turbidity, and other pollution defining criteria, as specified in the "Water Quality Standards and Stream Classification" adopted by the Water Quality Control Commission of Colorado, effective June 14, 1974.

In the event of conflict between these requirements and pollution control laws, rules, or regulations of other Federal, State, or local agencies, the more restrictive laws, rules, or regulations shall apply.

(continued)

The requirements of this Water Quality Plan shall be adhered to on all project-related activities, and not just those within the project limits. These activities include, but are not limited to, grouting, temporary haul roads and bridges, borrow areas, aggregate processing, concrete batching and placement, temporary culvert installations, prioneed roads, drill roads and drilling operations, and clearing and grubbing operations.

(b) CONSTRUCTION REQUIREMENTS

1. The Engineer may direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams, lakes, ponds, or other watercourses or water impoundment areas.

2. The Contractor shall assign a full time Erosion Control Water Quality Supervisor whose responsibility will be to fulfill the obligations outlined below.

   A. Have under his authority all necessary labor and equipment to direct and channel new drainages which may develop on a daily or hourly basis into suitable temporary pollution and erosion control features. This unit shall also be assigned the responsibility of creating suitable temporary pollution and erosion control features wherever necessary and of dismantling those features when their purpose has been fulfilled. The area in which these features were constructed shall be returned to a condition reasonably similar to that which existed prior to its disturbance.

   B. Be immediately available upon the Project Engineer's request to implement necessary actions to reduce any anticipated or presently existing water quality or erosion problems resulting from construction activity. The criteria by which the Project Engineer initiates this activity may be based on water quality data derived from monitoring operations outlined in this plan or by any anticipated conditions (e.g., predicted storms) which the Project Engineer believes could lead to unsuitable water quality situations.

   C. Be available to the Project Engineer to implement suitable winter shutdown procedures as directed and determined by the Project Engineer.

(continued)

3. The Contractor shall prepare schedules for accomplishing temporary and permanent erosion control work. These schedules shall be applicable to clearing and grubbing, grading, bridges and other structures to control water, construction, and paving; and shall be submitted at the preconstruction conference. He shall also submit his proposed method of erosion control on haul roads and borrow pits and his plan for disposal of waste material. Work shall not be started until the erosion control schedules and methods of operation have been approved.

   Included in this schedule should be information pertaining to a format for communication (i.e., hourly, daily, weekly) between the Project Engineer and the Contractor's Erosion Control/Water Quality Supervisor covering matters such as:

   A. How readily available he will be to the Project Engineer upon the latter's request?

   B. How much time will be required to assemble the necessary men and equipment from other aspects of construction?

   C. How many men will be under the direction of the Erosion Control/Water Quality Supervisor?

   D. What units of equipment will be available and given priority for utilization in constructing temporary pollution and erosion control features, or work related thereto?

   The Contractor shall have available upon request appropriate equipment as outlined in the approved plan.

4. Actions deemed necessary by the Project Engineer shall be given high priority in implementing necessary actions in controlling adverse water quality conditions. The Erosion Control/Water Quality Supervisor, at the Project Engineer's request, must make immediately available all men and equipment judged appropriate by the Project Engineer to maintain suitable water quality. These actions taken by the Project Engineer take precedence over any other aspect of project construction which has need of this same manpower and equipment.

(continued)

5. Wherever directed by the Project Engineer, the Erosion Control/Water Quality Supervisor shall assist in the use of chemical settling agents in holding structures. These chemicals may be alum or separan or approved equal such that proper use will not lead to any adverse conditions concerning aquatic or terrestrial biota. Only minimum amounts of said chemical agents shall be used as analytically determined and only on holding structures located off the main stem of principal drainage. Application of said chemicals will be by spraying application or influent injection.

6. Approval of the Contractor's plan shall not relieve the Contractor of the responsibility for operating and maintaining temporary pollution and erosion control features in a safe and systematic manner and for repairing at his expense any damage to, or failure of, the pollution and erosion control features.

7. Where erosion is likely to be a problem the surface area of erodible earth material exposed at one time shall not exceed 750,000 square feet for clearing and grubbing and 750,000 square feet for earthwork operations, without approval by the Engineer.

(c) MONITORING

1. In order to assure adherence to this Water Quality Plan, the Division will collect samples from the principal drainage, a minimum of once daily. Samples will be collected above and below or at other designated locations within the construction area which may have impact on the water quality of principal drainage. Turbidities of these samples will be measured on a Hach 2100 A Turbidimeter which shall be provided by the Division.

2. Data collected from this monitoring will be made available to other agencies upon request.

(continued)

(d) MEASUREMENT AND PAYMENT

Temporary erosion and pollution control measures required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled, shall be performed by the Contractor at his expense.

Work performed to install temporary or permanent controls in accordance with the work as scheduled or as ordered, will be paid for at the proper contract unit price. Should the work not be comparable to the project work under the applicable contract items, the Contractor shall perform the work on a force account basis.

STATE DEPARTMENT OF HIGHWAYS

CHAS. E. SHUMATE • EXECUTIVE DIRECTOR

STATE OF COLORADO

DIVISION OF HIGHWAYS		DISTRICT 3
E. N. HAASE		R. A. PROSENCE
CHIEF ENGINEER		DISTRICT ENGINEER

P.O. BOX 2107–606 SO. 9TH ST. • GRAND JUNCTION, COLO. 81501 • (303) 242 2862

I 70-2(38)
Vail Pass

January 30, 1975

7750

Mr. Tom Evans, Supervisor
White River National Forest
Glenwood Springs,CO 81601

Dear Tom:

Mo Barz, Vernon Leonard, Tom Arnold, and I met yesterday in what I felt was a very useful discussion of water quality problems associated with I-70 construction projects over Vail Pass. We hope everyone in your office and at the Regional Forester's level realize how anxious we are to keep water quality in Black Gore Creek at the highest possible level during the next two or three construction seasons. We would also solicit your understanding of the complexity of the problem caused by the types of soils in the area and constraints imposed by the steep terrain of the Black Gore drainage basin.

~~This letter is our assurance that we intend to fully implement all parts of the Water Quality Plan which is part of the contract documents on all forthcoming District 3 I-70 Vail Pass projects.~~ We feel that this letter of assurance is all that is needed to supplement the Water Quality Plan.

We intend to assign a full time Erosion Control/Water Quality Specialist to the projects involved. The critical nature of the projects with respect to controlling erosion and maintaining water quality demands that all phases of construction be monitored continuously. We are presently searching our rosters for an individual with proper credentials for this position. If we are not successful in locating someone within our organization, we shall go outside to locate a qualified individual.

continued...................

The Specialist shall be qualified through training and experience to deal effectively with situations that could adversely affect the environment. He shall be familiar with:

(1) the dynamics of water runoff and sedimentation, whether due to natural conditions or storms that cause sudden, unpredictable impacts;

(2) pollution defining criteria associated with water quality;

(3) the erosive characteristics of soil to enable him to determine control measures (structural and non-structural) to use with varying soil types;

(4) the source and availability of materials to control erosion and maintain water quality.

He shall be completely familiar with the concepts outlined in the Landscape and Erosion Manual. He must be capable of analyzing a situation and directing the action necessary to minimize the impact.

The Specialist shall be responsible for the collection and analysis of water turbidity samples from the principal drainage affected by each project. The purpose of taking the samples is to determine the effects that construction activity has on water turbidity. His project assistants shall use discretion in determining when to take the samples so as to reflect the impact of activities within the project limits.

The Specialist will rely on the analysis of water samples to stay within the permitted turbidity limits. The time lag between sample taking and analysis will be held to a minimum. Should State Water Quality Standards be exceeded, the Forest Service Liaison Officer will be notified immediately. A permanent record of analysis data shall be kept, and made available to the Liaison Officer when requested.

The line of authority for the Specialist will be through the Project Engineer, except that in cases of emergency, the Specialist wil be authorized to act on his own initiative. The Project Engineer has the authority to delegate to the Specialist as he sees fit.

continued...............

Each ongoing project will have sufficient personnel in the technician grades to assist the Specialist in meeting his responsibilities. These technicians may have other responsibilities, but if conditions warrant action, their first responsibility shall be to water quality control. Each shall have the following qualifications and duties:

a. Have sufficient knowledge and ability, through training or experience to monitor the Contractor's operation and detect any possible contributors to soil erosion and degradation of water quality.

b. Be completely familiar with the concepts outlined in the Landscape and Erosion Control Manual. While erosion control and water quality matters will be his primary concern, land scaping for aesthetic purposes may be among his assigned duties.

c. Promptly report to the Project Engineer or Specialist any construction activity that is, or has the potential of, creating a serious erosion or water pollution problem. His judgment and ability should enable him to recommend satisfactory solutions.

d. As a minimum, take daily water turbidity samples above and bedow his assigned project(s). The taking of additional samples will be required at times and locations as directed by the Liaison Officer, or when visual observation detects an increase in turbid water that was not previously monitored.

In order to provide training that is needed to fully acquaint Division personnel with water quality principles, we shall sponsor a water quality training course around the third week of March. Mr. Bill Word of our Environmental Division is drafting a course with the assistance of our hydrology section. We hope that your people will provide input, and perhaps even participate as instructors. We plan to invite contractor representatives to this short course on water quality.

We hope that this letter of assurance from a responsible state agency, with whom the Forest Service has had a good working relationship for many years, will quiet the doubts about our commitment to effectively handle water quality problems on I-70 Vail Pass projects.

Very truly yours,

E. N. HAASE
CHIEF ENGINEER

BY R. A. Prosence
R. A. PROSENCE
DISTRICT ENGINEER

RAP:lmw
CC: FHWA
Capron-Cox, Vernon, Atchison,
Marschel, Nimon, Heathcote
file

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